THE STORY OF A PIECE OF COAL.

CAN any of my listeners form any idea of what a million of years means? It is very difficult, I grant, but I cannot give any more definite conception of my own great age than by saying I am many millions of years old. You must therefore take it for granted that all this immense lapse of time has occurred since I was born. Before I attained my *majority*—that is to say, before I became really and positively *coal*—I had existed in manifold forms, more numerous and varied than the metamorphoses of the butterfly. You cannot hit upon a greater mistake than to suppose I was originally made just what you now see me—a jetty mass of mineral. The doctrine of metempsychosis, said to be held by the Hindoos, would apply almost literally to my own biography. You may trace my career through a hundred different stages, each more widely various than the other. Nay, the process of elaboration through which I have passed is so complex that I may well be forgiven if I have not a clear recollection of it myself.

I am English born and bred, notwithstanding the tropical character of my antecedents. In some measure, it may be thought that I hardly partake of English characteristics as regards the climate which affected my earlier career; but I can assure you I was never once removed from British ground. In the distant ages to which I have briefly referred, my recollections go back to waving forests of tree-fern and gigantic club-mosses, as well as to a thick underwood of strange-looking plants. The name now given to this formation by geologists is termed the Carboniferous, and you may form some idea of the ages which have flowed away since then by the fact that no fewer than *nine* subsequent distinct formations and periods occurred. These are known as the Permian, Triassic, Liassic, Oolitic, Cretaceous (or chalk), Eocene, Miocene, Pliocene, and Quaternary, to say nothing of the epoch comprehending the human race. To make myself still more clearly understood, it is necessary to state that the formations *newer* than that to which I belong attain a vertical thickness of more than fifty thousand feet! All this mass was slowly formed by gradual deposition along old sea-bottoms, while a more than equivalent period of time was taken up in the upheaving and other processes which have elevated these rocks into their present position!

The climate and geography of Great Britain were very different from what they now are when I was born. You must imagine a soft, balmy temperature, neither too hot nor too cold, and lacking those extremes which at present characterize the seasons. There was no great necessity for extreme heat—rather it was most important to the growth of a luxuriant vegetation to be free from cold. There were few ranges of hills or mountains, for these always cause a refrigeration of the atmosphere by condensing the clouds; thus hanging the sky with a curtain which shuts off a great deal of solar heat. True, right across what is now central England, there stretched a hilly barrier, which separated two coal-formations going on contemporaneously. Scotland and Wales were also then widely different from what these countries are at present. Instead of the grand mountainous scenery they now possess, we had long-extended saline mud-flats, thickly studded with trees now extinct, and know to the geologist by the names of *Sigillariæ*, *Lepidodendra*, and *Calamites*. In fact, all the district now considered as "coal-yielding" was then similarly circumstanced. The entire area had a geographical condition similar to the marine swamps which now fringe the coast-line of the Southern States of America. To these the slowly ebbing and flowing tides had access nearly twice a day. Around the more aged trunks of these extinct trees, standing on a muddy, shallow sea-bottom, so to speak—marine worms clustered, and their coiled tubes are now occasionally found fossilized, along with the petrified vegetation to which they clung when in life. These *Spirorbi*, as they are commonly termed, are tolerably plentiful in the north of England. It was owing to the semi-marine, semi-terrestrial character of the area on which the luxuriant vegetation of the Carboniferous period grew, that we now find so many fossil muscles and other marine shells embedded in the same strata.

I am told that chemists nowadays have discovered only one atom or particle of carbon associated with every thousand of the other gases forming the atmosphere. The atmosphere of the period when I was born hardly contained more. This small quantum was absorbed by the waving forests into their structure, and thus added to their solid bulk. Day by day, and year by year, each individual tree grew, so that the mass of solidified carbon increased, but without exhausting the original store. This was constantly being furnished by volcanoes, as well as by the lowly animals of my own time. Every thing, they say, is composed of minute and cellular parts, and originally my atoms freely floated in the air as so many particles of carbon. This was before I had entered into that combination which made me part and parcel of a living tree. Once having been sucked into the leaf-pores of a *Lepidodendron* or *Sigillaria*, I started existence under a new form. I became subject to those unknown laws of vital force which philosophers find so great a difficulty in explaining. I had now an active duty to perform, and had to assist in the growth and well-being of the tree in whose bulk I lay. But this did not prevent me from noticing the many strange objects which surrounded me. Human beings there were none, nor did the race to which I am now so useful an auxiliary appear upon the earth's platform for millions of years afterward. Tree-lizards, not very much larger than those which haunt the sunny banks of old England, climbed up and down the sculptured branches of the forest-trees, and lived upon the marsh flies and beetles, whose "drowsy hum" was the only sound that broke upon the stillness of these primeval woods. They found a shelter in the hollow trunks of *Sigillariæ*, in association with the pupæ of beetles and other insects. In some places they have been found fossilized together—a conserved recollection of those bygone times. Great reptiles, much resembling a frog, only as large as a small ox, waddled to and fro over the extensive

beaches, and left their enormous hand-like impressions in myriads upon the yielding mud. As such they are now found in the flaggy sandstones which compose the strata of the coal-formation. Occasionally, when overtaken by death, their carcasses rotted on the shores, and were embedded in the sands, to be found in long-subsequent ages in a fossil state. Several species of these gigantic batrachians existed contemporaneously. Very frequently the salt-water reaches were visited by alligator-like animals, now termed *Archægosaurus*, whose bodies were covered by hard, horny scutes or scales, held together much after the manner a slater now adopts when he tiles a house. These reptiles were five and six feet long, and, together with the great frogs I have mentioned, were the principal and most powerful animals of the age I am speaking of. The atmosphere differed little from its present condition, being neither denser nor more rarefied. This you may prove for yourself by the impressions of rain-drops preserved in the Carboniferous sandstones. The great drops were driven by the wind aslant, so that even now there is indicated the very quarter from which the wind blew at the time! The passing shower over, the sun peeped forth from behind the dark clouds, and his heat baked the mud, and cracked it, just as he does now the bottom of a clayey pond. These sun-cracks were subsequently filled up, sometimes by sand of a different color, so that they are fossilized as truly as the shells and plants. The same sandstones yet bear the trail-markings which the marine worms left after they had crawled over them when in a soft state. Occasionally you may even come across their burrows or holes; while the flagstones also are impressed with ripple-marks left by the retreating tides!

Although the sea-bottom was so shallow in the neighborhood of the great forests, I should state that many miles farther out it gradually shelved deeper, until there was an area where "blue water" was attained. Here the sea was fairly alive with animals of all sorts of natural history orders and classes. Coral banks, with animals putting forth their beautifully colored tentacles, more various than the rainbow hues, stretched over many leagues of old Devonian rocks, and, as the area was slowly submerging at the time, their united labors, in the course of ages, produced no small portion of what is now termed the "Mountain Limestone." Shell-fish, allied to the existing nautilus, found in these purer waters, free from land sediment, the essentials of their well-being. In the limestones which their dead shells helped to form there are no fewer than thirty different species of nautilus! They had relatives termed *Goniatites* (long since died out, for they did not possess the hardiness of their congeners), whose chambers were fashioned in a zigzag or angular manner. Then came another group of shell-fish, equally near by blood, the *Gyroceras*, whose coils did not lie so closely together as those of the nautilus. One other class of cephalopods are now known as *Orthoceratites*. They were also chambered, but were straight instead of being coiled. The limestones of this age are crowded with immense numbers both of species and individuals belonging to these genera. Of them all the *Orthoceras* was perhaps the most dreaded, partly on account of its size (some of their shells being three feet long, and as thick as a man's leg), and partly on account of their voracious habits. Fancy them, as I have frequently seen them, with their last chamber surrounded with a fringe of long arms, each of which was furnished with suckers that would indicate no slight danger to bathers nowadays! Hundreds of thousands of these creatures existed. Indeed, they were the scavengers of the Carboniferous seas, eating up every thing that came in their way, and perhaps not particular about preying upon a weakly brother when appetite prompted them. In Scotland, in many parts of the limestones formed at this time, the strata, for hundreds of feet in thickness, are composed of hardly any thing else but the accumulated shells of *Orthoceratites!*

At the bottom of the sea in which these cephalopods lived and flourished there were gathered together immense shoals of a peculiar shell called *Spirifera*, now extinct. Scores of species of this particular shell lived and died there, for it was the period when the family attained its maximum of existence. In fact, they occupied the place in those earlier seas that cockles and muscles do now. Their anatomy was very peculiar, each shell-fish being furnished with a peculiar coiled-up apparatus which it could protrude so as to produce currents that brought to it its food. Small but beautiful crustaceans, of a race then fast dying out, still swarmed the waters. Formerly they were known as *Trilobites*—those of this age are christened *Phillipsia*. Their family had exercised a sort of molluscan oligarchy during previous geological epochs. But the carboniferous period saw the last of the race, and its limestones became their tomb. I am told that the geologist knows few fossils more beautiful than these little trilobites. The cream-colored matrix in which they are embedded, and the perfect and ornate characters of the fossils themselves, cause them to be greedily collected and much admired. In the same sea were hundreds of species of shells besides, all of which thronged together to enjoy a common life; but to mention them separately would be to convert my story into a tedious detail. I should be lacking greatly in memory, however, if I were not to mention a most abundant and peculiar family, allied to the star-fishes and sea-urchins of the present day—I mean the *Crinoids*. The common feather-star of recent seas most resembles the upper parts of these extinct animals. But the tentacles of the latter were longer, while each was subdivided into branches. When at rest, these closed around the body like the petals of a tulip. Again, each was fastened to a jointed stem, which anchored itself by roots to the sea-bottom. Submarine forests of these crinoids covered many square miles of the rockier portions, and their graceful outlines and motions in the water, as well as their bright colors, were sufficient to induce admiration. In Derbyshire the limestone is almost entirely composed of their broken and aggregated stems.

As these dead shells and other animal remains accumulated along the ocean-floor to form a limestone that should afterward be easily identified by their embedded forms, almost every individual was coated by minute sea-mats. No Honiton lace of the present day ever excelled in grace and elegance that which belonged to these lowly animated beings. In the solid masses of the carboniferous limestone you may now find them festooning shells and corals; and few objects afford greater delight to the geologist when he comes across them. The *single* corals also—that is to say, those which did not grow in reefs, but lived solitary on the sea-bottom—were not inferior in beauty to any now existing. Their fringe of gorgeously-colored tentacles made them appear like so many animated flowers; and thus the dark caves of ocean then bore many a flower that was born to blush unseen. Slowly, through countless myriads of years, the carboniferous limestone increased to its present thickness, principally by the accumulation of dead shells! The sea-water contained more or less of carbonate of lime, which the shell-fish absorbed in order to build their dwellings, just as the trees did carbon that they might form wood. In this way the minute particles became ultimately condensed into rock masses. Meantime, the water was animated by little creatures that would have evaded human eyesight, although their forms were not a whit less elegant and graceful than those of their larger neighbors. Their tiny shells fell to the sea-bottom, and there formed a limy mud, which acted as a fine cement for the bigger fossils. As time passed on, the sea actually became shallower, by reason of the vast numbers of organisms lying on its floor. The weight of sea-water pressed them into a solid limestone rock, such as you now behold it. Can you wonder, after this, that such a deposit should take a high polish when worked, or that the marble thus produced should be speckled and marked by so many strange forms as you see it in your mantel-pieces or pillars?

In the shallower waters of the sea, and sometimes even in the marine lagoons where the trees grew, multitudes of strangely-clad fishes swarmed. The largest of these, the *Megalichthys*, or "great fish," possessed characters which linked it to the reptile family. Its teeth and jaws rendered it a formidable assailant, and its powerful build and rapidity in swimming made it the terror of its neighbors. In fact, the "great fish" occupied a place among the fishes of its time similar to that held in modern rivers by the pike, its size, also, averaging about the same. Time, however, would fail me to enumerate the various kinds of fish that lived in the same epoch that I did. From four or five feet in length, to thousands no bigger than the common stickleback, all were covered with enamel plates instead of horny scales. Indeed, horny-scaled fishes did not come into existence for ages afterward. In many parts of Lancashire, in the shales which overlie the coal-seams, these shining enamelled plates may be turned up by the thousand. The smaller fishes haunted the shallower lagoons overhung by club-mosses and ferns, and the dim light that broke through these was often reflected from the sheeny mail of *Palæonisci*, as they wantoned and gambolled, unaware of "great fish" lying near. When the muddy bottoms of these reaches and lagoons became afterward hardened into coal-shale, the dead fishes lying there, whose hard covering had protected them from decay, were entombed and passed into a fossil state.

But what tongue can describe the vegetable wonders of the forests where I grew? The woods were so thick, and the gloom so impenetrable in consequence, that it required a keen eye to make out individual peculiarities. Fancy *Lepidodendra*, four or five feet in diameter, and as much as fifty or sixty feet high, and yet nothing but gigantic "club-mosses!" Their long leafy ribbons waved like the leaves of the aspen, and, where these had fallen off, the bark was most gracefully and geometrically reticulated from their attachment. Thirty or forty different sorts of these immense club-mosses existed at the same time, each characterized by different leaves and bark. The gigantic *Sigillariæ* were nearly related to them, the main difference being their longer leaves, straighter stems, and the larger marks made on the bark. The roots, also, of this latter class of trees were very peculiar, and stretched through the mud on every side, seeking a firm foundation for the tree to which they belonged. Shooting many feet above these great club-mosses were huge "mares' tails," as easily distinguished from the rest as the wavy poplar nowadays is from oak and elm. These are called *Calamites*, and, truly, they were extraordinary objects. You have only to magnify the little "mares' tales" growing in ditches until you see them fifty and sixty (or more) feet high, and you would have the best restoration of these calamites that could be imagined. There were many species, characterized by fluted joints and by difference of foliage. Here and there, but more sparsely scattered, were graceful tree-ferns, whose former fronds had left great scars on each side the trunk. The higher grounds were occupied by peculiar species of pine, bearing great berries as big as crab-apples. The humid morass was densely covered by a thick underwood of smaller ferns, which grew there in rank abundance. The equable temperature, rich soil, and humid atmosphere, were just the needful accessories to the growth of vegetation of the class I have mentioned. It consequently flourished at a rate of which we can form but a poor idea from the present. The accumulated trees, ferns, etc., were very great, and these gathered in immense quantities over the entire area. I mentioned before that there was a slow sinking or submergence going on. Well, occasionally, the tides brought up silt, and strewed it over the decomposing vegetation. In fact, many of the forests were actually buried thus, and their trunks are frequently met with standing erect in solid sandstone rock. But though the covering-up of the vegetation prevented the liberated gases from escaping, it also obstructed for a time the growth of other trees. The latter could not well flourish on sand-banks, and so they were limited to conditions elsewhere similar to those I have mentioned. But, as time elapsed, the old circumstances returned. Another forest grew on the site of the older, to be buried up in its turn. During countless ages this alternate growth and covering-up went on, until in some places, as in the South-Wales coal-field, there are no fewer than one hundred different seams of coal!

After this vegetation had been thus collected, chemical changes began to take place. The mass heated and turned black, just as a stack of hay does now when it has been packed in a damp state. By-and-by, it was transmuted into a pulpy condition, wherein almost all traces of vegetable structure became lost. It afterward changed into a solid sub-crystalline mass, and obtained the jetty, semi-cubical character it now presents. As many of the tissues of coniferous trees contain more or less of silex, which is indestructible, it follows that, when coal is burned, this drops out of the grate as a white ash. When the microscope is applied to it, the peculiar spiral and dotted vessels of these ancient trees are plainly visible. But notice the associations which cling to a piece of coal! It represents a more solid condition of carbon than is to be found in mere wood. And here I should state that, though various conditions of fossil fuel are met with, from green wood to culm and anthracite, their vegetable origin is never once lost sight of; while Chemistry steps in with an easy statement of how these changes occurred! The ancient vegetation of the coal period grew by virtue of the stimulus of the sunlight. The heat and light induced growth, and thus even a piece of coal represents so much fossil sunshine. And now, when men light their fires or manufacture their gas, they are but setting free the light and heat of the sun which poured down on the old carboniferous forest, and were stored up by the vegetation in their tissues. Nay, more, botanists will tell you that the three primary colors of light are sure to be developed at some time or another in the history of every plant or tree—in the blue and yellow which form the green of the leaves, and in the red of the fruit or russet of the bark. Just so with the fossil vegetation termed coal. The very aniline colors which are obtained from coal-tar are nothing more or less than the restoration of the primary colors which the ancient vegetation stored up from the light. Such is a portion of my history, briefly sketched; but the broad traces of design manifested in my preparation are too palpable to be overlooked. The age in which I was born was a special one, like to none other which went before or came after; and it is to me that modern progress is indebted. In my mass is stored up a force that saves the wear and tear of human muscle and sinew, that does away with the fearful toil which makes simple slaves of men, and enables them to gain daily bread by easier means. But, through the vast ages during which I have been silently stowed away, plutonic disturbances have repeatedly broken through and cracked the solid strata, and have thus brought them to the surface to enable men to work the coal they contain. Meantime, life in its manifold phases has never once been absent; while its upward progression culminated in a being endowed with moral and mental as well as physical perfections, and it was for him and his kind that I was specially prepared, to surround him with the means of social happiness and comfort, and to enable him to rise higher in the scale of intellectual being.